CLAIMS

1. A method of determining measures of cardiac function in a patient including the steps of;

   (i) generating an alternating current signal at multiple simultaneous frequencies from a constant current source electrically isolated from the patient;

   (ii) applying the current to an outer pair of electrodes on the patient;

   (iii) measuring a voltage signal across an inner pair of electrodes on the patient;

   (iv) demodulating the current signal and voltage signal to extract signals at each of said multiple frequencies;

   (v) determining impedance at each said frequency at a time;

   (vi) fitting said impedance at each frequency to a theoretical frequency dependent impedance locus;

   (vii) extrapolating the locus to obtain a value of impedance at zero frequency at said time;

   (viii) repeating steps (v) to (vii) to obtain a time varying plot of impedance; and

   (ix) calculating measures of cardiac function in the patient from said time varying plot.

2. The method of claim 1 wherein said multiple simultaneous frequencies comprise at least three frequencies of stimulation.

3. The method of claim 1 wherein said multiple simultaneous frequencies comprise at least five frequencies of stimulation.

4. The method of claim 1 wherein said frequencies fall within the range 2-2000 kHz.

5. The method of claim 1 wherein said frequencies fall within the range 10-500 kHz.

6. The method of claim 1 wherein the frequency and waveform of the alternating current signal is selectable or fixed.

7. The method of claim 1 wherein the current signal and the voltage signal are demodulated using Fast Fourier Transform.

8. The method of claim 1 wherein the Fast Fourier Transform of said current signal and said voltage signal provides a phase value and an amplitude value from which impedance is determined.

9. The method of claim 1 further including the step of recording an ECG and correlating the ECG with the time varying plot of impedance.

10. The method of claim 1 wherein the change in the impedance value over time and the rate of change in the measured impedance signal dZ/dt is used to determine impedance parameters to calculate cardiac output of said patient.

11. The method of claim 1 wherein a time derivative of said impedance signal is mathematically obtained using the extrapolated impedance at zero frequency (Z_0) or at infinite frequency (Z_{inf}).

12. The method of claim 1 wherein the theoretical frequency dependant impedance locus is a Cole-Cole analysis.

13. The method of claim 1 wherein steps (i) to (viii) are repeated to record at least one cardiac cycle.

14. The method of claim 1 wherein measures of cardiac function are calculated using the following equation:

$$SV = \frac{\rho L^2 \langle dZ / dt \rangle_{\max} VET}{Z_B^2}$$

where: SV = stroke volume

$(dz/dt)_{max}$ = maximum rate of change in measured impedance at the beginning of systolic cycle

VET = left ventricular ejection time.

15. The method of claim 1 wherein measures of cardiac function are calculated using the following equation:

$$SV = \frac{L'^3 \langle dZ / dt \rangle_{\max} VET}{Z_B}$$

where: SV = stroke volume

$(dz/dt)_{max}$ = maximum rate of change in measured impedance at the beginning of systolic cycle

VET = left ventricular ejection time

L'= thoracic length estimated from the subject's height and weight using a nomogram

L' = blood resistivity.

16. The method of claim 1 further including the step of measuring and recording the distance between the inner electrodes.

17. The method of claim 1 further including the step of measuring and recording the height, weight, sex and age of the patient.

18. The method of claim 1 wherein the steps of demodulating and determining an impedance at a time, comprises the steps of:

sampling the impedance signals to obtain a sampled impedance;

applying a time to frequency domain transform to said sampled signal to obtain transformed impedance signals; and

filtering the transformed impedance signals and isolating each frequency to determine the impedance for each frequency at each time.

19. An apparatus for non-invasive measurement of cardiac function in a patient, said apparatus comprising:

a constant current source, electrically isolated from said patient, generating an alternating current signal at multiple simultaneous frequencies, which is applied to an outer pair of electrodes on a patient;

an inner pair of electrodes applied to a patient for measuring a voltage signal;

signal processing means for converting said applied current signal and measured voltage signal to impedance signals at each frequency at a time;

means for determining impedance values at a zero frequency (Z_0) and at infinite frequency (Z_{inf}) at a plurality of time intervals; and

means for calculating measures of cardiac function in said patient from said impedance values.

20. The apparatus of claim 19 wherein said outer pair of electrodes comprise shields to protect the patient from stray current.